An expert advisor for vocational guidance

Joachim P. Hasebrook[1] and Wolfgang Nathusius[2]
[1] Bank Academy, Oeder Weg 16-18, D-60318 Frankfurt
[2] Medialog Corp., Kolpingstr. 18, D-68165 Mannheim

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We developed a multimedia program which combines a vocational encyclopedia and a testing facility to foster adequate career decisions. The testing facility is designed to suggest the same careers which a given number of experts would have suggested, if presented with the same user's input. Our vocational database includes imprecise data like expert ratings enabling the calculation of suggestions of career options. The most important group of users of software for vocational guidance are young adults, who are about to leave schools. The results of cluster analyses (n=426) show that the interests of students are poor structured and are not compatible with experts´ ratings. The test facility has been implemented on several CD-ROMs, a short quiz to identify occupational fields, and a wide range of surveys which are responded by letters. 43 students participated in an experiment to investigate the understanding and acceptance of the information provided by the system. The results show that students are able to judge, whether careers match their individual interests or not. Furthermore, we explore whether the system is able to reconstruct 38 experts´ ratings. The system shows a good performance in reconstructing the experts´ data – except of one academical career which was not described very clearly. In a recent study, we tested the influence of the testing facility on recall of information and individual acceptance (n=75). Acceptance and recall of information about career options is clearly enhanced when studying individualized materials compared to more general information.

Introduction

Many people feel a lack of competence in career decision making. A lot of programs provide help but most of them cover selected topics and are judged to be of poor quality (Katz, 1993; Bridges, 1989). We developed a multimedia program which combines a vocational encyclopedia and a testing facility to foster adequate career decisions. The testing facility is designed to maximize the probability to suggest careers which a given number of experts - based upon the same user input - would have suggested. The testing facility and the vocational encyclopedia have been implemented on microcomputers using Windows 3.1, Windows 95, and on UNIX machines.

Although knowledge based systems and intelligent tutoring system (ITS) are well established tools, there are hardly any implementations of systems for vocational diagnosing and counseling (Ueckert, 1995). Psychological testing procedures including computer-supported diagnosis are used to conduct aptitude tests in personnel selection (e.g. Ghiselli, 1973; Sweetland & Keyer, 1984; Funke, 1993), adaptive testing optimizing economy and performance of personality, aptitude, and ability tests (e.g. Cronbach & Gleser, 1965; Park & Tennyson, 1983; Weiss & Vale, 1987; Bennett, 1993), and decision analysis applied to management diagnostics (Nagel, 1993; Sonnenberg, 1993).

Although there are numerous tests which check for individual interests (e.g. Todt, 1967; Irle & Allehoff, 1984), ability (ITB, 1988a+b, Deidesheimer Kreis, 1993), and aptitude (Fock & Engelbrecht, 1986), there are hardly any computer-based, psychological testing procedures addressing vocational guidance. This does not mean, however, that there are no software products available: Counseling software guides list 200 programs, approximately, that are designed to support self assessment, job finding, and job keeping (Walz, Bleuer & Maze, 1989; Katz, 1993). About 70 titles incorporate surveys or self-testing facilities in order to provide the user with information about his or her career alternatives and career satisfaction. Most of these program address restricted topics like nursing professions or writing successful job applications. Additionally, many programs are judged to be of a poor quality in terms of completeness, accuracy and counseling efficacy (Bridges, 1989). Despite several shortcomings career counseling software is considered to be useful:

- The software can offer both instruction and practice (e.g. interviewing for jobs).
- Some programs have quizzes or exercises allowing an evaluation of career maturity or job hunting skills.
- The program can access information from large databases of occupational fields or careers.
- A large group of software allows users to answer questions about likes and dislikes and match them to careers.
- Some of this programs take the repetitive work and tedious jobs away from the counselor, hence, enabling him or her to focus on interactive career counseling.

The most common complaints regarding these programs are (Katz, 1993; Bridges, 1989):

- Poor usability in terms of screen layout and functional design,
- long response and searching times,
- a lack of adaptability to the audience,
- too few or inadequate assessment questions,
- and a lack of complete and up-to-date information.

Therefore, we decided to develop a program to support career decision making and to provide a comprehensive collection of relevant and up-to-date vocational information.

Models for vocational guidance

Recent tendencies of the job market force young adults to acquire a high qualification in order to get adequate jobs. Additionally, the transition from school to work life gets more difficult and protracted. Therefore, improvements in educational and psychological counseling are required (Büchtemann, Schupp & Soloff, 1993). A core concept of career counseling is the assessment of vocational interests and abilities. Interests play an important role in career decision processes. They are considered to be that part of the self concept that matches personal traits and job structures (Allehoff, 1985). Therefore, vocational interests are effects of cognitive decision processes when judging about objects and actions which are relevant for jobs. Bergmann (1992) found reliable correlation between the dominating personal traits and the profession. These findings are theoretically explained by person-environment models which suppose that people tend to reduce dissonance between personal and environmental conditions (Holland, 1985).

Vocational interests of young adults

The most important group of users of software for vocational guidance are young adults, who are about to leave schools. An important factor of career decision making is the knowledge young adults can access to in order to come up with valid decisions. 426 pupils participated in two studies designed to identify structures within job related interests and aptitudes (Hasebrook & Gremm, 1996). The results of a cluster analysis of 156 items show that the interests of pupils from secondary schools are poor structured and do not fit the situation on the job market: Production, technical equipment, and the notion of "dirty work" form one cluster, "clean" and social professions form another cluster. Working in offices, e.g. commercial professions, are supposed to be between "dirty" and "clean" work. Students of high schools have even simpler images in mind when judging about jobs in crafts and industries: They simply divide in "dirty" and "clean" jobs, and they are much more fond of getting a clean job than students of secondary schools are. Academical jobs, however, were described in complex and highly interrelated patterns. Figure 1 displays the results of the cluster analyses conducted with the data from highschool students judging non-academical jobs. This structure is compared to the structure derived from the experts´ ratings.

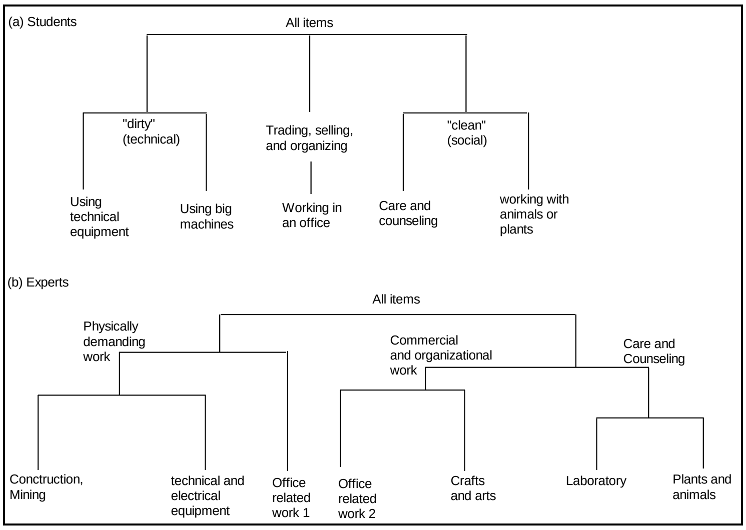

Figure 1. Results from two clusteranalyses: (a) high school students judging about non-academical professions (n=157), (b) experts´ ratings of non-academical professions and educational programs (n=118).

Knowledge and system engineering for vocational guidance

Students are novices with respect to career decisions, because they have no experiences which help them to evaluate their own vocational orientation. Experts tend to be over-specific and cannot take a "naive" point of view. Thus, an ideal system supporting vocational guidance should reduce and transform inputs from experts and students into profiles which can be compared automatically. Based upon this considerations a system to support career decision making can be constituted by an interactive test or quiz to match interests and preferences with job characteristics, and an encyclopedia or database to inform the user about relevant job characteristics like tasks, educational programs, work load, income, and so on. Our decision support system is not designed to mimic the full range of an interpersonal counseling process. Rather, it shall provide the user with a variety of career options which match his or her personal interests and preferences. The knowledge engineering process covered five project phases:

1. The relevant factors of the experts´ reasoning about careers were identified using interviews and surveys. More than 800 German careers and educational programs, about 50 items like „Is this job physically demanding?“, and 118 interviews with experts were included in this first step.
2. The data revealed from this investigations were reduced to dimensions that discriminate between careers by means of statistical measurements. We calculated Principal Component Analyses (PCA) which are standard procedures of multivariate statistics in order to identify main sources of variances in multi-dimensional data sets (Stevens, 1992). We identified seven factors for academical career and nine factors for non-academical careers. Thus, 16 factors are sufficient to calculate discriminating profiles for each career in our expert system.
3. We wrote short statements like „I would like to explain new products to customers“ which were dedicated to describe one of our 16 factors. 12 Items per factor were written

and reviewed by a team of eight vocational experts resulting in an item pool of 192 statements.

4. 426 students filled in surveys about their state of information, their vocational interests and responded to our item pool. By means of a multiple regression procedure (Stevens, 1992) we identified those items which described a single factor most clearly. This step resulted in a reduced item pool of 80 statements, 5 items per factor.
5. In the last step, we implemented a database containing relevant information about 800 German careers and educational programs: Task descriptions, special demands, agenda of educational program, income wages, prognostic data, and the job profile relying on the reduced expert data.

The database serves a the basis of our expert advisory system. In particular, we aimed to meet the following conditions:

1. The probability should be maximized that our system generates the same list of careers which our 118 experts would have suggested, if presented with identical input data.
2. The implemented module should be small and fast – that is, the program should be small enough to be stored on a single floppy disc including basic data about 600 German professions and educational programs; additionally, system response times should not exceed 2 seconds.
3. The model should be able to incorporate information from our vocational databases like average income, prognostication of the job market etc.
4. The data of the model should be updated and maintained easily. This is a crucial point for all systems supporting career decisions, because vocational databases have to be updated and modified quite frequently.

Calculating the goodness of fit

The core component of all career guidance systems is to inform the user about the goodness of fit of his or her vocational interests and a variety of career options. Katz (1993) tries to give a feedback about goodness of fit by performing a multiplication of self-ratings and expert ratings (as shown in formula [1]).

[1] $$\gamma = \sum R_{Self} \cdot R_{Expert}$$

Self-ratings (R_{Self}) refer to the variations of the importance attached to each dimension by the user, e.g. how much she or he likes team-oriented working. Expert ratings (R_{Expert}) are judgments of experts about how important each dimension is in every-day work life, e.g. the proportion of time spent by team-oriented work. More sophisticated models rely on a measurement of the distance between self rating and expert rating. These model mostly use the City-Block distance or other forms of Minkowski metrics [2].

[2] $$\delta = \left[\sum \left|R_{Self} - R_{Expert}\right|^{C}\right]^{\frac{1}{C}}$$

Parameter c has to be greater than or equal to 1; with c=1 the term calculates the City-Block distance and with c=2 the Euclidean distance is calculated. Simple distance models, such aas describes in [1] and [2], have several shortcomings: (a) The functions are not monotone and the distances measurements are far from being equi-distant. (b) There are no information about positive or negative matches but only about how much self and expert ratings fit. (c) It is hard to introduce preference models, e.g. to take into account whether a certain item or dimension is judged to be more or less important compared to another item or dimension. (d) The scores expressing distances between self ratings and expert ratings cannot be compared directly – that is, scores derived from multiplication like in [1] and Minkowki metrics like in [2] are probably *not* contained in comparable scales. An of the paradox consequences of these simple distance models is that the more conflicting interests the user has got the more careers are fitting the user's profile. Consider a user who states that she or he likes to work in an office and at the same time she or he likes to work open-air. According to Minkowski metrics all careers are appropriate that can be carried out either in an office or open-air. A more adequate response would be to suggest careers that fulfill both conditions: partly to work in an office and partly to work open-air, e.g. security staff in big companies.

AI models to match careers to individual interests

As mentioned before, there were no systems at hand based on classical AI methods to guide or implementation process (cf. Ueckert, 1995). We reviewed rule-based expert systems, neural networks, genetic algorithms, fuzzy logic, and advanced statistical systems in order to check their appropriatnes for our purposes.

1. Neural networks are superior to many statistical methods because they provide an easy way for non-linear forecast. They are effective in recognizing patterns in noisy or incomplete data. Therefore, neural networks are suited for career counseling where clear rules cannot be formulated (Weiss & Kulikowski, 1991). Unfortunately, it is impossible to explain the reasoning of neural networks to users. Explanation of the underlying reasoning, however, is a crucial point in career counseling.
2. Genetic algorithms are successful in searching huge databases and large optimization problems including timetabling, job-shop scheduling, and data-mining. Moreover, genetic algorithms can provide explanations of the decisions they produce (Davis, 1991). The performance of genetic algorithms, however, is strongly affected by the representations schemes employed. Additionally, setting the parameters such as mutation rate and crossover need extensive experimentation. This contradicts our goal to develop a algorithm which is simple to use and simple to maintain.
3. One of the obvious advantages of fuzzy systems is their capability to deal with imprecise data using a rule-based knowledge base which is easy to understand and explain. This advantage, however, tuns out to be a problem if clear rules can not be elicited (Cox, 1994).
4. While interviewing 118 experts for career counseling, we learned from the interviews that the experts use rules to guide the counseling process, but they do not rely on any detectable rules when matching career options and personal traits. Thus, we had difficulties to translate their expertise into simple If-then-rules.

Our statistical analysis of the expert data revealed that only very few statistically significant factors are discriminating hundreds of career options. We aimed to take advantage of this fact and reviewed statistical methods to match multi-dimensional data sets. We looked for an algorithm which allows easy explanation of reasoning, easy updating and maintainance, and incorporation of precise and imprecise data. Above all, no paradox results should be obtained by the system.

Implementation of the expert advisor

We developed a system which embedded the following components:

1. An easy quiz or test about vocational interests and experiences.
2. Rating data and dimensions derived from a PCA (Principal Components Analysis; Stevens, 1992) of the expert ratings.
3. An algorithm based on a GLM (General Linear Model) to compare user and expert ratings.
4. A component to enter additional preferences and to modify the results of the GLM.
5. Finally, a report module generates an assorted list of suggested professions or careers.

Although there are more comprehensive databases about educational programs in Germany than ours (e.g. KURS direkt, 1995), our database is the only one which includes imprecise data like expert ratings enabling the calculation of commendable career options. There are two ways to incorporate additional information into the calculation: (a) Precise data like student fees and income wages are considered by looking up the appropriate data tables. (b) Imprecise inputs like individual preferences are used to modify the distances measurements. Figure 2 gives an overview of all components of the testing facility.

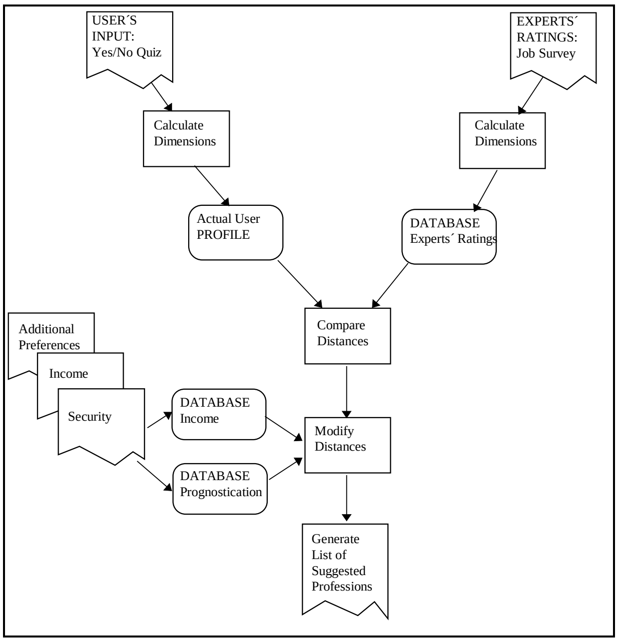

Figure 2. Components of the testing facility supporting career decision making by matching individual interests and job characteristics.

We decided to rely on distance measurement models from multivariate statistics providing information about strength and direction of matches, enabling easy modifications and transformations into appropriate scales. The most simple form to express a directed goodness of fit is to calculate a linear regression. We choose the covariance (formula [3] with μ being the arithmetical mean of the ratings R).

$$\rho = \frac{1}{n}\sum\left(\left(R_{Self} - \mu_{Self}\right)\cdot\left(R_{Expert} - \mu_{Expert}\right)\right)$$

$$= \frac{1}{n}\sum\left(R_{Self} \cdot R_{Expert}\right) - \mu_{Self} \cdot \mu_{Expert}$$

[3] $$r = \frac{\rho}{\sigma_{Self} \cdot \sigma_{Expert}}$$

This score expresses the distances of the ratings by means of the squared distances of individual ratings and the arithmetic mean and can be transformed into statistically comparable values. The covariance ρ can be adapted to the standard deviations of the ratings (σ_{Self} and σ_{Expert}) – resulting in the linear correlation coefficient *r* – and can be fitted to the normal distribution by a Z-transformation [4] – resulting in the value Z (Stevens, 1992).

[4] $$Z = \frac{1}{2}\ln\left(\frac{1+r}{1-r}\right)$$

Z expresses an directed and normalized measurement of the linear fit of self ratings and expert ratings within a range from -1 (negative fit) to +1 (positive fit). As the Z-value is fitted to a normal curve, it can be used even in sophisticated statistical procedures (Stevens, 1992; Bennett, 1993). Profiles of single careers can be included in or excluded from the database without affecting the comparison algorithm. The system does not produce paradox results because conflicting interest ratings lead to a general decrease of the correlation coefficients. Furthermore, the coefficients can be easily adapted to individual importance ratings attached to different dimensions: In one implementation of our expert advisor (see next section) the users could move sliders from 0 (low preference) to 100 (high preference) to express the importance of their ratings. Our system represents variations of the importance attached to each dimensions by an modified covariance formula [5] with λ being the importance rating (e.g. raging from 0 to 100):

[5] $$\rho = \frac{1}{n}\sum \left(\frac{R_{Self} \cdot \lambda - \mu_{Self}}{\sum \lambda} \right) \cdot \left(R_{Expert} - \mu_{Expert} \right)$$

After having been modified the covariance can be used in statistical procedures like normal covariance coefficients. Finally, Z-values (see [4]) allow for an exact definition of the cut-off point separating career options that match individual interests from those that do not: We defined the peak of the Z-value distribution (the „bell curve“) to be the cut-off criterion. The peak can easily be calculated by comparing the differences between the Z-values of two neighboring careers: The peak of the distribution is reached when the preceding difference is smaller than it’s successor.

System implementation and product development

The model described in figure 3 has been implemented on UNIX-computers using the programming language C because of its portability. This C-program was modified, extended, and incorporated in several products: A series of CD-ROMs for Windows-PC, a short quiz to identify occupational fields, and a wide range of surveys which are responded by carefully commented letters containing 10 to 15 pages each.

Medialog produces a series of eight CD-ROM for microcomputers equipped with Windows 3.1 or Windows 95. Each CD-ROM applies to a certain occupational field like “Economics and Law”, “Natural Sciences”, and so on, and contains a vocational encyclopedia combined with the testing facility. In the beginning of a session the user enters his or her personal qualifications and conditions in order to allow the program to come up with reasonable suggestions and information. The user decides whether he or she wants to examine occupational fields, to explore the index of the encyclopedia, or to take a job quiz. The quiz provides the user with up to 80 simple yes/no assessments. After having responded to 20 items the system signals to the user that it is ready to suggest jobs and educational programs. If the user accesses the list of suggested items he or she may jump into the encyclopedia by a simple mouse click and retrieve information about qualifications, tasks, work load, income, prognoses, and so on. All occupational fields and many jobs are illustrated by videos and photos in order to elaborate the text and give an realistic impression of work life (Hasebrook & Graßl, 1995). Figure 3 displays a block diagram and a screen shot of the graphical user interface of the CD-ROM.

A multimedia program containing our testing facility has been produced and published in charge of an international bank. The program contains a wide range of information: In the final version the program informs the user in short about 300 jobs and educational programs, psychological testing procedures, preparing job applications, studying in Europe and North America, how to improve decision making, and about 1500 relevant addresses. Furthermore, the program is equipped with a testing facility combining preferences concerning interests, income, and job security: The user can take a quiz about his or her interests responding up to 60 questions. Two sliders enable the user to compare his or her interests (1) to the preference to get a high income and (2) the preference to get a high job security. The slider can be put into any position between "0" (less important than interests) to "100" (more important than interests). The user can choose between lists of suggested job fields, single jobs, or university studies. A short description can be accessed for each suggestion.

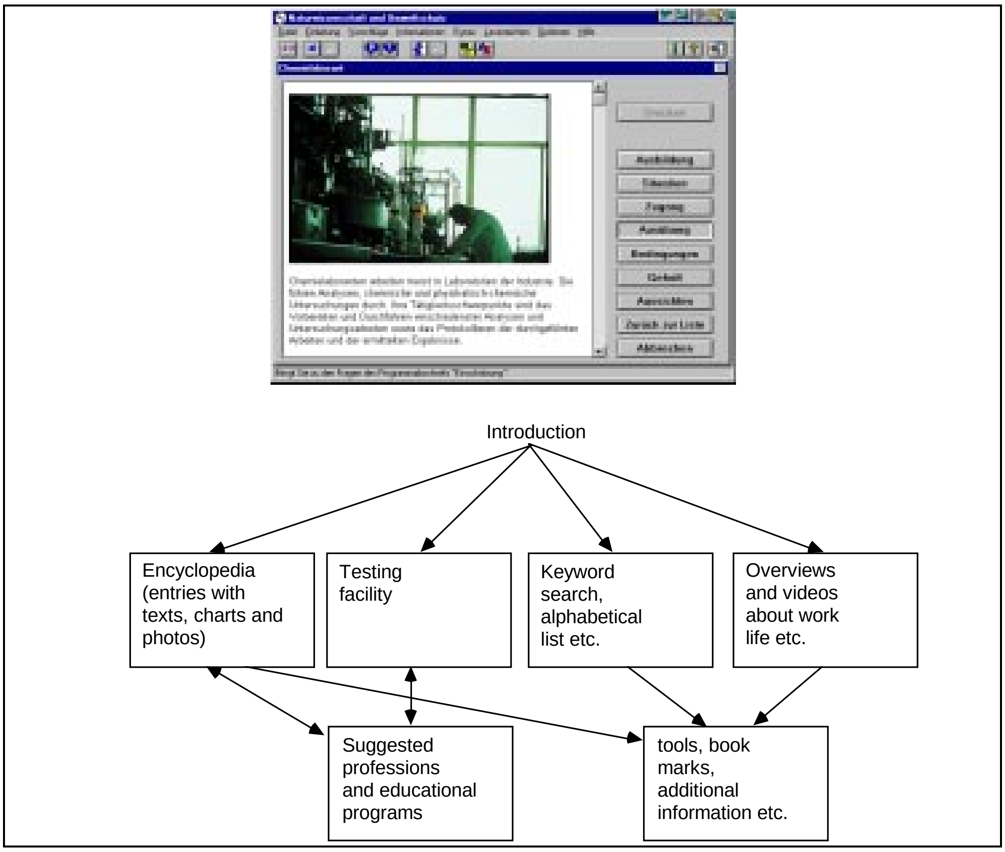

Figure 3. Block diagram and screen shot of the CD-ROM “Career Counselor” with Yes/No quiz, list of suggested professions, and information from a vocational encyclopedia (screen displays an entry of the encyclopedia).

A third version of our system has been implemented in charge of a international chemical trust. The company wants to present its educational programs and career opportunities in schools motivating students to start their career in the chemical industry. The program is used as a point-of-information with a sophisticated graphical user interface including maps, charts, photographs, and sounds. As there are hardly any menus and buttons, the screens contain lots of interactive elements: clicking on a map calls for information about regions and cities, clicking on a photo illustrating a certain profession accesses further information concerning the depicted profession. The testing facility consists of 28 questions focusing on the educational programs of the company. Each questions can be answered by moving sliders between "I totally disagree" to "I completely agree". The system calculates up to five suggestions based on the direction and the strength of the user´s valuation of the questions. Figure 4 displays a block diagram and a screen shot of the program.

Evaluation of the expert advisor

There are several psychological inventories dedicated to measure career development and vocational maturity. One goal was to make valid prognostications of the career development and the vocational success. Most of the studies, however, show essential validity for short-term predictions, only. Therefore, most investigations focus on enhancing construct validity. High construct validity, however, gives little support to career decision making and vocational guidance (Seifert, 1994). Therefore, we evaluated our testing facility for its practical validity – that is, how are the system´s responses accepted by students and counseling experts. 43 students participated in an experiment to investigate the understanding and acceptance of the information provided by the system. Furthermore, we explore whether the system is able to reconstruct 38 experts´ ratings.

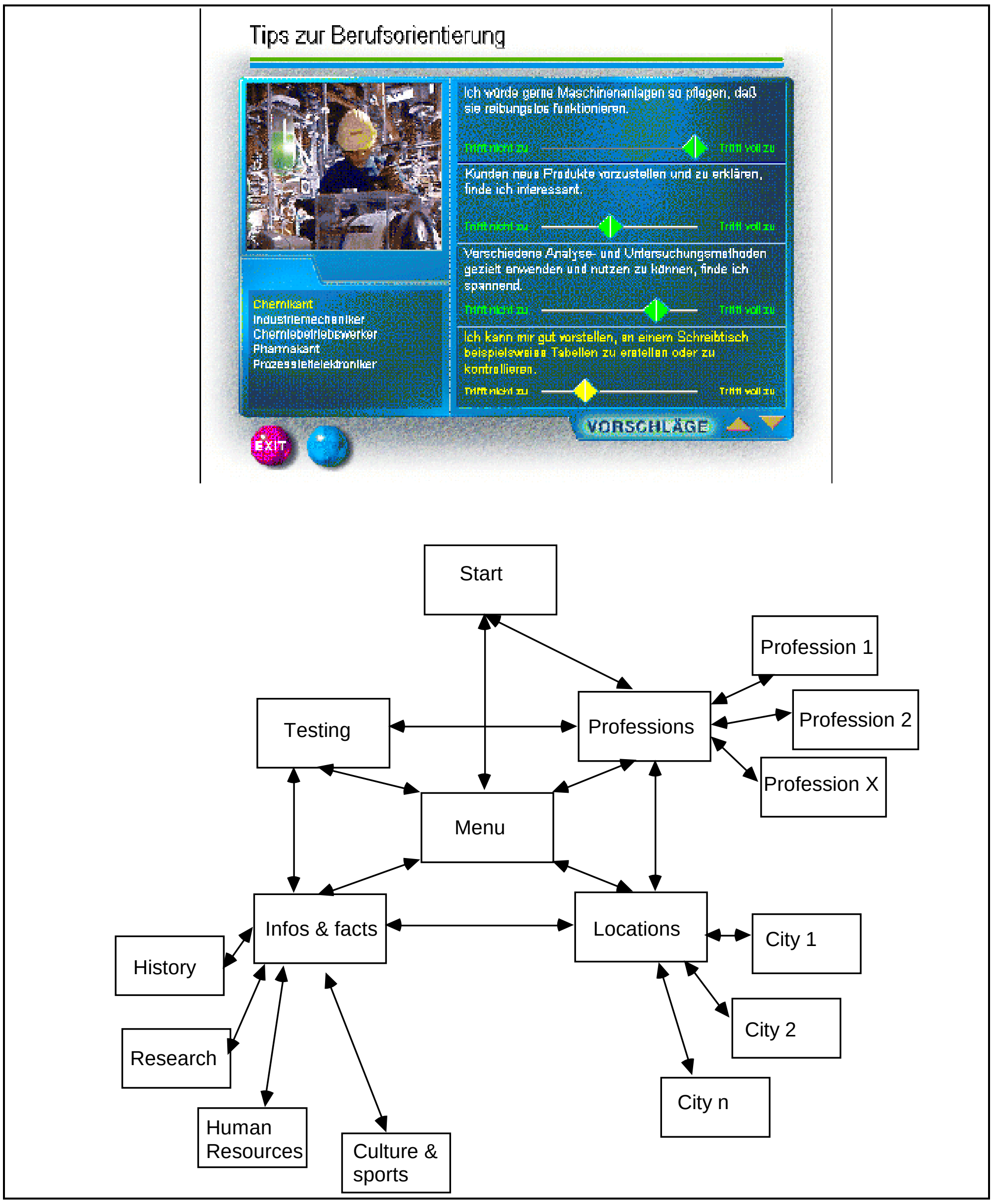

Figure 4. Block diagram and screen shot of a point-of-information about the educational programs of a chemical company (screen shot displays testing facility with sliders and list of suggested programs).

We asked the students to rank four different job lists according to their judgment, whether the lists match their vocational interests or not. The students were told that the four lists were generated by four different computer programs. In fact, only one list was calculated by our computer system, three list contained random selections: A short random list with 6 suggestions, a long random list with 20 suggestions, and a list with a random selection of 12 popular jobs. The results show that students are able to judge, whether careers match their individual interests or not (cf. figure 5): They preferred individually calculated job lists compared to random lists ($F[3,122]=11.8$; $p<.001$; $Eta^2=.23$). But they were not able to tell them apart from the list which consists of popular jobs which do *not* match their interests. Therefore, the students´ judgments rely on weak criteria (sometimes) leading them to wrong conclusions.

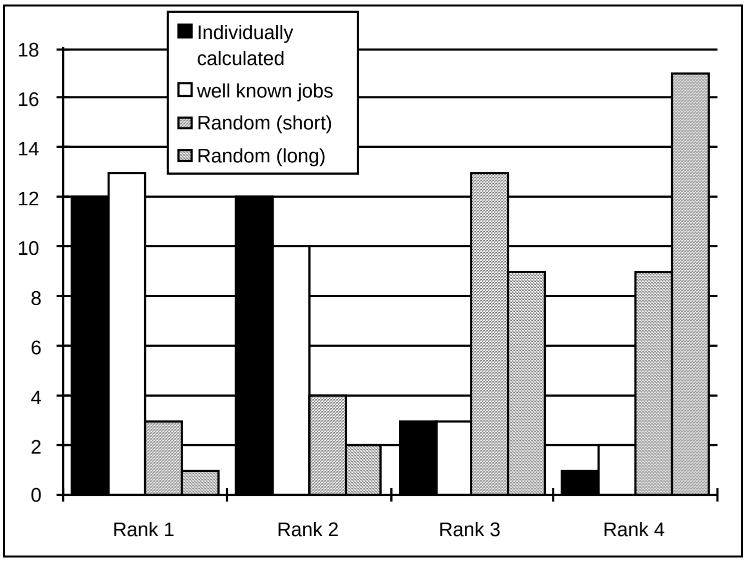

Figure 5. Students prefer individually calculated job lists – but they cannot tell them apart from well known, generally preferred jobs, which do *not* match their interests (n=29).

This assumption is confirmed by the data displayed in table 1: There is a positive correlation between the students´ judgments about...

- how well the suggested jobs match their interests,
- how well they know the suggested jobs (based upon concrete information),
- and how well they can imagine what typical professionals are doing.

However, there is a negative correlation between all these variables and the actual state of information: The more information the students have got, the less they are willing to accept suggestions – and the less they have got a notion of knowing. Therefore, information leads to more skepticism and critics. And skepticism may help to guide the career decision making process more carefully.

Table 1

Correlation between questions concerning acceptance of the suggested jobs & information about jobs (n=43).

Content of question:	Match	Know	Imagine
Match			
Know	0,56		
Imagine	0,42	0,58	
Information	-0,49	-0,36	-0,34

More information makes students more critical and keen to get more information. This is the result of a study in which 156 high school students participated. The students filled in a survey about their actual state of information and their need for information. Figure 6 displays the main results: Those students who are not engaged in information seeking (14%) are not very likely to change their attitude, only 32% of this small group want to collect more information. On the contrary, nearly 100% of the best informed group (19%) is fond of receiving more information about their career options.

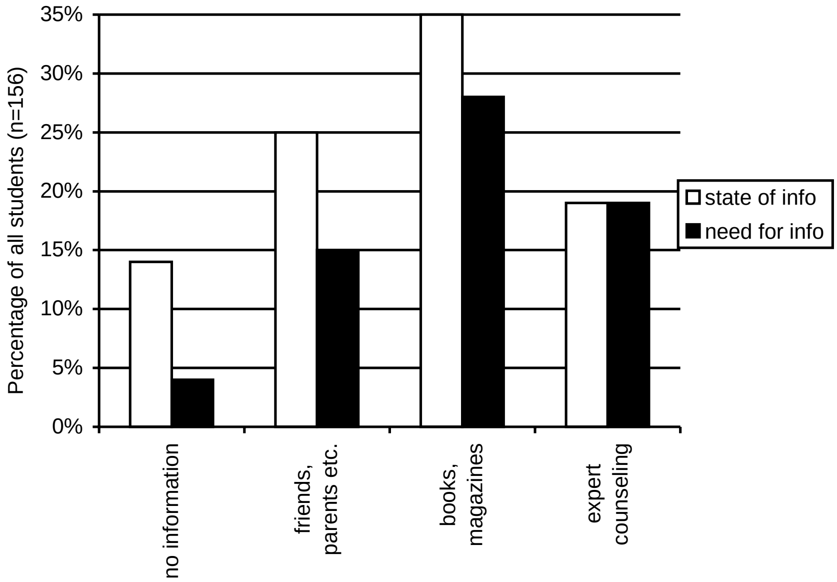

Figure 6. Students who have gathered more information are fond of getting even more: 100% of the 19% best informed students want to receive more information. However, only 32% of the students, who are currently not engaged in information seeking (14%), plan to do so in the future (n=156).

38 experts were instructed to respond to the yes/no assessments of our testing facility like ideal professionals from their point of view would do. The system shows a good performance in reconstructing the experts´ data – except of one academical career which was not described very clearly: The system correctly identified between 85% and 100% of the experts´ ratings (academical career 42%). Adjusted goodness of fit scores (AGF) of a LISREL model were between 0.81 and 0.92; AGF scores greater than 0.8 indicate a high goodness of fit. (Jöreskog & Sörbom, 1989).

In a recent study, we tested the influence of the testing facility on recall of information and individual acceptance. The testing facility enabled the participants to enter their vocational interests and to receive a list of suggested jobs and educational programs from a multimedia encyclopedia. Additionally, all participants received the same list of jobs. The study has two parts: During the learning phase the participants read information about jobs and educational programs; during the testing phase, all participants completed two surveys: (a) They rated the overall acceptance of the program, its functions, and its information; these results are summarized in table 2. (b) They completed a cued-recall task which consists of five questions about the job's description, income, distribution of age groups, usability indices, and unemployment rates; these results are displayed in table 3.

The results confirm that individualized information effects acceptances ratings positively ($F[1,73]=8.38$; $p<.01$): The students considered all information about recommended jobs to be more interesting and valuable. Additionally, recall is clearly enhanced when studying individualized materials compared to general information ($F[1,73]=13.9$; $p<.01$; $Eta^2=.16$): Students tend to recall more information about careers that match their individual interests.

Table 2

Acceptance ratings (0=complete acceptance, 25=complete rejection) as a function of list of jobs (previously fixed list vs. individually generated list).

	Job list		
	Previously fixed		Individually generated
Tasks, motivating	2.2		2.5
Tasks, valuable	2.8		2.9
Income, motivating	2.5		2.6
Income, valuable	2.6		2.7
Prognoses, motivating	2.5		2.7
Prognoses, valuable	2.7		2.8
Summarized score	15.3		16.2

Table 3

Cued recall scores (0=no recall; 25=complete recall) as a function of list of jobs (previously fixed list vs. individually generated list).

	Job list		
	Previously fixed		Individually generated
Recall job title	2.2		2.7
Recall income	1.4		2.7
Recall age groups	1.4		1.8
Recall usability index	1.2		2.0
Recall unemployment	1.4		2.3
Summarized score	7.6		11.5

Conclusion

Multimedia have potentials to enhance and facilitate career decision making. Most of the recent multimedia systems, however, show small positive effects or none at all. The effective use of multimedia is influenced by many internal and external factors, like motivation, knowledge, mode and contents of media, learning strategies, features of the task, etc. (Hasebrook, 1995). Making multimedia applications effective means to start from the user's perspective: Mostly, this implies to conduct a study about needs and abilities of the intended users (Hasebrook & Gremm, 1996; Glowalla & Hasebrook, 1995).

Expert advises provided by the system clearly increases acceptance and performance of the system: Users pick up more information about career options that match their interests and they consider this information to be more valuable. The more information they have gathered and elaborated the more the loose their notion of knowing and develop a critical approach to expert advisory. Multimedia applications should not be designed to provide "something for everyone", but they should provide exactly that piece of information which is needed in a particular state of the decision making process. Multivariate statistical methods can complement (or partly replace) AI methods where they are not fully applicable.

Our system does not address the students´ inability to make reasonable judgments as a whole but tries to motivate careful consideration of as many career options as possible. In order to achieve this goal system responses have to be valid in terms of the students´ understanding and the experts´ valuation. Three steps of the development of our testing facility ascertain its validity: (1) a comprehensive database containing precise and imprecise data, (2) examination of the items and testing procedures with the intended users, and (3) applying an adequate algorithm which refers to expert knowledge. Recently, a German bank charged us to develop a new testing facility addressing career decision making amongst non-students, namely professionals who want to make a shift within their company (e.g. Goodwin & Hoppin, 1988). In the future, we will test whether our approach can be extended and applied to different target groups and career options.

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